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ABSTRACT

This study conducted an econometric analysis of the impact of the University of Delaware (UD), a public, doctoral level institution, on the Delaware economy, particularly the impact of nonresident students. To construct a model the study used historical institutional data from the Office of Institutional Research and Planning at UD and macroeconomic data from the Department of Commerce and the Bureau of the Census for the period 1979-91. In applying the model to the 1991 academic year the study noted that 11,235 nonresident and 9,633 resident students attended UD paying $122 million in tuition and fees. During that year UD spent $290 million in operating educational expenditures, of which $194 million were spent in salaries and wages, including benefits. During this period UD employed 3,651 persons and state appropriations were $68 million. This study used a linear regression model with predetermined endogenous variables and with exogenous variables selected from the collected data. The model indicated that in 1991-92, UD students and employees induced $27 million and $60 million, respectively, in wages and salaries in other sectors of the state economy. In addition, the model suggested that nonresident students induced $18 million, of the $27 million, in wages and salaries in other sectors of the Delaware economy. The paper concludes that this analysis method is more usable than the commoner but more complicated models. (Contains 58 references.) (JB)

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ECONOMETRIC ESTIMATION OF THE ECONOMIC IMPACT OF A UNIVERSITY

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by

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Jean Endo
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Econometric Estimation of the Economic Impact of a University

Abstract

In this study the least squares and Hoerl-Kennard ridge estimators are used to measure the impact of the University of Delaware (UD) upon the Delaware economy. The variables modeled are UD employment, UD wages, and total wages in sectors of the Delaware economy outside of UD. Results indicate that, in 1991-92, UD students and employees induced $27 million and $60 million in wages, respectively, in other sectors of the Delaware economy. Of the $27 million, nonresident students induced $18 million in wages in the local economy. The methodology used can be applied to any other institution to measure its regional economic impact.

Econometric Estimation of the Economic Impact of a University

Introduction

The purpose of this study is to conduct an econometric analysis of the impact of the University of Delaware (UD), a public, doctoral level institution, upon the Delaware economy. The impact of UD nonresident students on Delaware's economy is measured, in particular. Historical institutional data (Office of Institutional Research and Planning) and macroeconomic data (U.S. Department of Commerce; U.S. Bureau of the Census), for the period 1979-91, is collected to construct the model. In the Fall of 1991, 11,235 nonresident and 9,633 resident students attended UD paying $122 million in tuition and fees. During 1991-92, UD spent $290 million in operating educational expenditures, of which $194 million were expended in salaries and wages, including benefits. During this period UD employed 3,651 persons. State appropriations during this period were $68 million.

Literature Review

Most university impact studies are based on the well-known deterministic model proposed by Caffrey and Issacs (1972). The Caffrey-Issacs full model measures positive and negative regional economic impacts of higher education institutions, but is costly to implement. Sturm (1990) proposed a modified version of the Caffrey-Issacs model. Sturm does not account for negative economic impacts in order to enable small institutional research offices to conduct economic impact studies at a lower cost. Salley (1978) presents a short survey of impact studies conducted using economic base models. Elliott, Levin, and Meisel (1988) discuss the objectives and methodologies of economic impact studies and offer some guidance in the design of such studies. Smith and Bissonnette (1989) describe a cost-benefit analysis of the impact of nonresident students on West Virginia's economy.

The regional economic impacts of institutions of higher learning can also be estimated using input-output analysis (Leontief, 1972). However, input-output modeling is a costly enterprise, and may not be a feasible alternative for small institutional research offices operating under a budget constraint. In addition, Goldstein (1990) discusses the use of input-output analysis for estimating the regional economic impact of universities and points out several limitations of input-output models, such as the need for large amounts of information.

Only a relatively small number of studies have used econometric analysis to estimate the regional economic impact of universities (Fishkind, Milliman, and Ellsen, 1978; Engler, Firnberg, and Kuhn, 1980; Olson, 1981; Brown and Johnson, 1987).

Methodology

In this study a linear regression model is developed, using the SAS System (SAS Institute Inc.), to analyze the impact of UD upon the Delaware economy. Hocking (1983) presents a brief survey of linear regression methodology. Each endogenous variable is regressed, using the ordinary least squares (OLS) method (Gauss, 1823), on some subset of exogenous variables selected from the collected data. The stepwise procedure (Efroymson, 1960) is not useful for selecting exogenous variables because of its instability and insensitivity to multicollinearity (Hoerl, Schuenemeyer, and Hoerl, 1986). Frisch (1934), the winner of the first Nobel Memorial Prize in Economics, was the first person to investigate the problem of multicollinearity. Piegorsch and Casella (1989) discuss the rich history of the use of matrix diagonal increments to ease the problem of multicollinearity. Multicollinearity may be a serious problem whenever an entering exogenous variable increases a variance inflation factor beyond 5 (Marquardt, 1970).

Ridge regression analysis (Hoerl, 1962; Hoerl, 1964; Hoerl and Kennard, 1970a; Hoerl and Kennard, 1970b), which has generated a large and influential literature (Hoerl and Kennard, 1981; Hoerl and Kennard,

1982), can be routinely used, even if ridge estimates are not desired, to ease the problem of multicollinearity by observing the behavior of the Hoerl-Kennard ridge traces. An important ridge regression example which was used as Exhibit 2073 in a federal court in Chicago, Illinois, on May 19, 1980, by the American Telephone and Telegraph Company in a $2.7 billion antitrust lawsuit by MCI Communications Corporation is discussed by Vinod (1976) and Vinod (1981, p. 203). For another interesting application see Hoerl, Kennard, and Hoerl (1985). Judge, Hill, Griffths, and Lee (1985), and Vinod and Ullah (1981) discuss the seminal ideas of ridge regression.

The variable selection process is not well-defined, because it is difficult to select, a priori, a set of structural equations representing the university's impact on the regional economy. Therefore, among several plausible subsets of exogenous variables competing to "explain" an endogenous variable, the subset which results in the smallest mean square error (MSE) is the one selected. The identification of MSE as an important criterion for choice among estimators can be traced to Gauss (1809). Two exogenous variables that are closely correlated with each other may be exchangeable in the model, but one of them may decrease the MSE substantially more than the other, and hence, become a candidate for entry into the model. A new entering variable may make some of the variables selected at earlier stages insignificant.

If the selected regressors are strongly intercorrelated, then ridge regression is used to ease the resulting problem of multicollinearity. Use of ridge regression to ease the problem of multicollinearity in equations having a relatively large MSE may amount to an abuse of ridge regression analysis. Since, the length of the OLS estimated coefficients is in general biased (Brook and Moore, 1980), ridge regression may lessen the risk of overestimating crucial economic impact multipliers. The tradition of unbiased estimation in Statistics began with the work of Gauss. In an interesting paper, Efron (1975) notes how "certain deliberately induced biases can dramatically improve estimation properties."

Any set of simultaneous stochastical equations (Haavelmo, 1943) that result using the "minimum MSE" variable selection rule is re-estimated using the three-stage least squares (3SLS) method (Zellner and Theil, 1962). If multicollinearity is a problem then, ridge-like methods for simultaneous estimation of simultaneous equations, such as the ridge 3SLS (R3SLS) method (Maasoumi, 1980), are used.

Cook's (1977) distance and DFBETAS (Belsley, Kuh, and Welsch, 1980) are used to assess the sensitivity of the model. Normality of the distribution of the estimated residuals can be assessed using the quantile-quantile plot (Wilk and Gnanadesikan, 1968). For an extensive discussion of sensitivity analysis in linear regression see Chatterjee and Hadi (1988). The described methodology makes the model robust. Gana and Hoerl (1993) have used this methodology to analyze an important historical data set.

A UD Impact Model

The predetermined endogenous variables are defined below.

UDEMPLOY	employment at UD.
UDWAGES	salaries and wages including benefits paid by UD.
WAGESOUT	salaries and wages in Delaware net of UDWAGES.

The exogenous variables selected from the collected data are defined below.

DECNMFE	earnings in Delaware's construction and manufacturing industries.
DENDOW	State of Delaware appropriations plus income from UD endowments.
EARNINGS	earnings accrued by aggregating farm, construction, manufacturing, wholesale and retail trade, finance, insurance, real estate, and service industries in Delaware.
GIFTSU	monies accruing from unrestricted gifts to UD.
UDENROLL	resident and nonresident student enrollment at UD.

UDENROLR resident student enrollment at UD.

UDREVNUE UD revenues from tuition and fees, endowments, state appropriations, unrestricted gifts and grants, and activities of educational departments.

All monetary variables are transformed to constant-dollar values using the gross domestic product implicit price deflator. The constant-dollar values can be improved if gross state product (Kendrick and Jaycox, 1965) implicit price deflators are available. Mathematical functions, such as those introduced by Box and Cox (1964), are not invoked to transform exogenous or endogenous variables.

The selected equations are specified below.

1. UDEMPLOY regressed on UDENROLL, DENDOW, GIFTSU.
2. UDWAGES regressed on UDEMPLOY, UDREVNUE.
3. WAGESOUT regressed on UDEMPLOY, DECNMFE.
4. WAGESOUT regressed on UDENROLL, EARNINGS.
5. WAGESOUT regressed on UDENROLR, EARNINGS.

Equations 1 and 2 are re-estimated using the 3SLS method, and equations 1 and 3 are re-estimated using the R3SLS method. The OLS estimate of the intercept term in equation 5, which is used to measure the impact of nonresident students, has a t-ratio of -0.45. This is an interesting practical example of a multicollinearity masking intercept term. The Hoerl-Kennard ridge estimator changes the sign of the estimated intercept term, and the system stabilizes when the biasing nonstochastic matrix diagonal increment attains the value 0.0134, beyond which excessive shrinkage of the regressor coefficients, reflected by rapid increases in MSE, will occur. Choice of the biasing matrix diagonal increment is also discussed by Mallows (1973), Obenchain (1975), Hoerl, Kennard, and Baldwin (1975), Hoerl and Kennard (1975), Lawless and Wang (1976), and Dempster, Schatzoff, and Wermuth (1977). However, one must be careful to ensure that some of these

choices do not result in excessive shrinkage of crucial economic impact multipliers. This issue is also reflected in a simulation study done by Gallo (1977).

The observed F-ratios for the estimated equations range from 282 to 2,587. The ratio of regression mean square to residual mean square in ridge regression equations cannot be interpreted as an exact F-ratio (Hoerl and Kennard, 1990) but, is important for comparing various ridge estimators. The recognition of the importance of large observed F-ratios can be traced to Wetz (1964) who suggested that observed F-ratios of "satisfactory" regression equations exceed the selected percentage point of the F-distribution by at least four times. The R-squared values for all equations are 0.98 or more, and there are no "influential" data values or variables.

Impact Analysis

Some of the estimated coefficients in the regression are interpreted as partial derivatives. It should be noted that, in general, the partial derivative interpretation of regression coefficients should be carefully considered because, in regression models of nonexperimental data which have not been rigorously constructed, such an interpretation may amount to an "abuse" (Box, 1966) of regression analysis.

Two multipliers derived in this study are the estimated coefficient of UDENROLL, 1,317, in equation 1, and the estimated coefficient of UDEMPLOY in equation 3, 16,456. These estimated multipliers indicate that, in 1991-92, UD students and employees induced $27 million and $60 million, respectively, in wages and salaries in other sectors of the Delaware economy. The third multiplier is the estimate of the coefficient of UDENROLR, 975, in equation 5. This multiplier implies that, in 1991-92, nonresident students induced $18 million, of the $27 million, in wages and salaries in other sectors of the Delaware economy. These results are consistent with the results from an input-output model developed by Black and Stapleford (1988), and indicate that UD has a substantial impact on Delaware's economy.

Conclusion

In an environment of severe budget constraints, there is an urgent need for higher education institutions to demonstrate their regional economic impact to governments and citizens in order to credibly compete for scarce state and community funds. Caffrey-Issacs type impact models are costly to estimate. However, econometric models can be accurately estimated at low cost, and can also be used by small colleges with one-person institutional research offices to measure their economic impact.

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